PAT-NO: JP360151311A

DOCUMENT-IDENTIFIER: JP 60151311 A

TITLE: POLYETHYLENE YARN CONTAINING LIQUID PARAFFIN

PUBN-DATE: August 9, 1985

INVENTOR-INFORMATION:
NAME
NANRI, SHOSUKE
KAWAGUCHI, TOKIO
YASUDA, HIROSHI

ASSIGNEE-INFORMATION:
NAME
TOYOBO CO LTD

COUNTRY
N/A

APPL-NO: JP59005394

APPL-DATE: January 13, 1984

INT-CL (IPC): D01F006/46, D02G003/36

US-CL-CURRENT: 428/398

ABSTRACT:

PURPOSE: The titled yarn useful as a rope, etc., having improved processing properties, frictional resistance, and wear resistance, having a flatness ratio of cross section of yarn of ≥ specific value, a great number of long channels arranged in the fiber axis direction on the surface, containing liquid paraffin having specific characteristics.

CONSTITUTION: Liquid paraffin is added to a solution obtained by dissolving

ultra-high-molecular-weight polyethylene in decalin, etc., the solution is
subjected to solution spinning, and the prepared gel fiber is drawn, to give
the desired yarn having ≥1.7 flatness ratio of cross section of yarn, a
great number of long channels arranged in the fiber axis direction, a liquid
paraffin content (LP) in the yarn of
0.05≤LP≤1.00(wt%), ≥30(g/d)
tensile strength, and ≥800(g/d) initial modulus of elasticity.

NB. multi-striate might be not the correct word (translator).

Public disclosure 60-151311, August 9, 1985
Patent application 59-5394, January 13, 1984
Applicant Toyobo Co., Ltd.

Specification.

1. Title of the invention.

A polyethylene fiber that contains liquid paraffin.

2. What is claimed.

1. A polyethylene fiber that contains liquid paraffin, with the characteristic that the rate of flattening of the cross section of the fiber is 1.7 or more, that the fiber surface has innumerbale longitudinal multi-striate grooves that have been arranged in the fiber's axial direction, and that it has the below mentioned characteristics.
The liquid paraffin content (LP) in the fiber is
$0.05 \leq LP \leq 1.00$ (wt%),
the tensile strength is 30 (g/d) or more, and
the initial elasticity modulus is 800 (g/d) or more.

2. The polyethylene fiber that contains liquid paraffin that has been described in claim 1, wherein the rate of flattening of the cross section of the fiber is 2 or more.

3. The polyethylene fiber that contains liquid paraffin that has been described in claim 1, wherein the rate of flattening of the cross section of the fiber is 3 or more.

4. The polyethylene fiber that contains liquid paraffin that has been described in each of the claims 1-3, wherein the longitudinal multi-striate grooves actually all tunnel through along the entire domain of the length in axial direction of the fiber.

5. The polyethylene fiber that contains liquid paraffin that has been described in each of the claims 1-4, wherein the longitudinal multi-striate grooves are arranged with 5-50 grooves per average distance of 10 μ in the direction of the outer circumference of the cross section of the fiber.

6. The polyethylene fiber that contains liquid paraffin that has been described in each of the claims 1-5, wherein the tensile strength is 35 (g/d) or more.

7. The polyethylene fiber that contains liquid paraffin that has been described in each of the claims 1-6, wherein the initial elasticity modulus is 1000 (g/d) or more.

3. Detailed description of the invention.

This invention pertains to a polyethylene fiber that contains liquid paraffin with excellent processability, and particularly excellent resistance against friction abrasion.
As a multipurpose macromolecule, polyethylene fibers are cheap, but because they have weak points such as not being dyable, having a low melting point and

being non moisture absorbing, their use for clothing is more difficult than that of other synthetic fibers such as for instance polyester, nylon, and acrylic fibers, and they are mainly used for other applications than the application in clothing, such as for instance general ropes and fishing nets. In these fields of application, particularly the damand as fibers for fisheries resources is large, because polyethylene fibers have a density that is lower than 1. When compared with other synthetic fibers and particularly with polyester and nylon etc., the strength of high density polyethylene rope that can be obtained, for instance in the case of ropes that are the final product, is only in the order of 70% of a polyester rope and of 50% of a nylon rope with the same diameter as that of the said polyethylene rope, and use in fields wherein strength is necessary, had limitations. In this way, the field of use of polyethylene fibers hitherto had limitations, and also the demand was limited. In the case of use of polyethylene fibers for clothing, on the other hand, it has been considered to improve the functions and performances that are unsuited for clothing or to use them as composites by combination with other fibers, making the most of the characteristics of polyethylene fibers. Based on this way of thinking, coming to make the most of the characteristics of polyethylene fibers, that they have a lower density than other synthetic fibers and in addition have a relatively high strength, is an advantage for use of polyethylene fibers for clothing.

The present inventors carried out serious research in order to solve the existing weak points of polyethylene fibers and to give functionality, making the most of the advantages of the said fibers, with the result that finally they achieved this invention.

That is to say that this invention is a polyethylene fiber that contains liquid paraffin with the characteristic that the rate of flattening of the cross section of the fiber is 1.7 or more, that the fiber surface has innumerable longitudinal multi-striate grooves that have been arranged in the fiber's axial direction, and that it has the below mentioned characteristics.

The liquid paraffin content (LP) in the fiber is

$0.05 \leq LP \leq 1.00$ (wt%),

the tensile strength is 30 (g/d) or more, and

the initial elasticity modulus is 800 (g/d) or more.

In the polyethylene fiber of this invention, processability from the viewpoint of use for clothing has been remarkably improved as compared with the existing well known polyethylene fiber, and in addition, it shows an extremely high tensile strenght and initial elasticity modulus, and an excellent resistance against friction abrasion, and of course, it demonstrates an excellent result in the strength and initial elasticiy modulus also as an industrial material. The reason that the processability of the polyethylene fiber of this invention from the viewpoint of use for clothing is remarkable excellent, is not yet positively clear, but it is guessed that the inherent flattening of the fiber cross section and the innumerable longitudinal multi-striate grooves that are present in the fiber's surface and that have been arranged in the fiber's axial direction, and in addition the liquid paraffin in the polyethylene fiber of this invention, greatly contribute hereto.

Figure 1 is a 1500 x magnified photograph by a scanning electron microscope that shows the side surface and cross section of a polyethylene fiber with a flattening rate of the cross section of the fiber that has been obtained by the first situation of this invention, of ca. 5.6. In the said photograph, the flattening rate of the characteristic cross section of the fiber of this invention, and the innumerable multi-striate grooves that have been arranged in the fiber's axial direction that are present in the fiber's surface, are very clear.

The polyethylene fiber of this invention has, as is shown in figure 1, a flat cross section, and the flattening rate is 1.7 or more, and preferably 2 or more, and more preferably 3 or more. The larger the flattening rate, the better

the property of bundling between the polyethylene fibers, and particularly the better the packing properties between the fibers in the case that a twist is given. The effect thereof is particularly demonstrated when a composite is made with other fibers. When the flattening rate is less than 1.7, this effect is small, and there is no wide difference from fibers with a round cross section of the fiber's cross section.

For the flattening rate (Ud) that is defined in this invention, the length of the long axis (a mm) and the length of the short axis (b mm) in the cross section that is perpendicular to the fiber's axis, are determined, and the flattening rate (Ud-super streep) is the value that is shown by a/b.

Another characteristic feature in this invention is that, as is shown in figure 1, the surface of the fiber has innumerable multi-striate grooves that have been arranged in axial direction of the fiber. Polyethylene fibers have the unique wax-like impression of synthetic fibers, and in the case of a flat surface, it gives a disagreeable impression. By the fact that the surface has got multi-striate grooves in the flat polyethylene fiber, this wax-like impression is reduced, and escape of moisture is improved. The result of this improvement of moisture escape demonstrates the role of transport of moisture in the case that it has been combined with other fibers. Moreover, when multi-striate grooves are given to the polyethylene fiber, the friction coefficient of the fiber surface declines, and friction resistance with metal of guides etc. declines, and abrasion of the fiber by friction is reduced. Moreover, in the case that it has been combined with other fibers, the entanglement with the other fibers is improved, and the bundles of polyethylene fibers in the combined fibers show a a flexible behaviour.

By the fact that the said multi-striate grooves are arranged with 2 or more and preferably 5-50 per average distance of 10 μ in the direction of the outer circumference of the cross section of the fiber, the above mentioned effect, viz., the effect of reduction of the wax-like state and of improvement of the escape of moisture, and the effect of reduction of the friction coefficient of the fiber surface etc., are remarkably improved. In the case that here the multi-striate grooves are less than 2 per average distance of 10 μ in the direction of the outer circumference of the cross section of the fiber, the effect of reduction of the wax-like state and of improvement of the escape of moisture, and the effect of reduction of the friction coefficient of the fiber surface are not obtained.

Another characteristic feature of the polyethylene fiber of this invention is that it contains liquid paraffin. The polyethylene fiber of this invention shows, in addition to the effect that depends on the fact that it has multi-striate grooves in the surface, a synergistic effect by the effect that depends on the fact that it contains liquid paraffin in the fiber, and the travelling tension of the yarn at the time of processing of the fiber is reduced and the damage of the yarn is reduced, and it is possible to obtain a stable

productivity. Moreover, also the product that is obtained with the use of the polyethylene fiber alone, shows a good resistance against friction abrasion.

A characteristic feature of the polyethylene fiber of this invention is that it contains liquid paraffin across the whole domain of the cross section of the fiber. Hitherto, a method of improvement of resistance against friction abrasion by the fact that liquid paraffin is given only to the surface of the fiber in the after-processing etc., is known, but in this case, the effect wears away in the course of time, and durability is not good. On the other hand, the fiber of this invention has an extremely excellent durability of the resistance against friction abrasion.

The content of liquid paraffin that is contained in the polyethylene fiber of this invention preferably is 0.05 wt% or more, but 1.0 wt% or less. A content of liquid paraffin that is less than 0.05 wt%, is not preferred because then the excellent effect of resistance against friction abrasion of the liquid paraffin is no longer observed. Moreover, a content of liquid paraffin that exceeds 1.0 wt%, is not preferred because in that case the fiber surface gets a slimy impression because the content of liquid paraffin is high, and at the time of fiber processing, liquid paraffin is accumulated in the running guide of the yarn, and the operationability deteriorates.

The content of liquid paraffin in this invention is obtained in the following way.

A prescribed quantity of polyethylene fiber is taken, and the liquid paraffin that is contained in the fiber surface and the inner surface is extracted with a solvent that dissolves liquid paraffin, such as petroleum ether, xylene and toluene, and the reduction of weight vs. the initial weight of the polyethylene fiber (weight before extraction with the solvent) is determined, and hereform, it is calculated. Moreover, the verification of the liquid paraffin is assessed by the infrared absorption spectrum.

The tensile strength of the polyethylene fiber of this invention has to be 30 (g/d) or more, and preferably 35 (g/d) or more, and when here the tensile strength is less than 30 (g/d), fine fibers and the effect of slimming(?) of the yarn by a high tension in the case that it has been combined for clothing are not obtained, and in the case that it is used for instance for ropes for industrial material, fine and tough ropes cannot be obtained.

The initial elasticity modulus of the polyethtlene fiber of this invention has to be 800 (g/d) or more, and preferably 1000 (g/d) or more, and when here the initial elasticity modulus is less than 800 (g/d), the entanglement(?) of the fibers is weak by the synergistic effect with the flattening of the cross section of the fiber, and in the case of combination with other fibers, a good appearance(?) is not obtained.

The fiber of this invention is obtained by the novel method of stretching to a high degree, that comprises that in solvent spinning with the use of for instance polyethylene with a high molecular weight (for instance polyethylene with an ultrahigh molecular weight with a weight average molecular weight of $1x10^5$ or more, and preferably $1x10^6$ or more), a volatile solvent is used as the solvent, that after adjustment of the spinning solvent by addition of a proper quantity of liquid paraffin so that the liquid paraffin content in the fiber after stretching in this solvent is 0.05 wt% or more to 1.0 wt% or less, solvent spinning is carried out, and that multi-step stretching is carried out while the gel fiber that has been produced by the by said solvent spinning is passed through a stretching zone wherein the temperature of the entrance of the stretching zone is set higher than the point of liquefaction of the supplied fiber, and lower than the melting point of the said supplied fiber, and the temperature of the exit of the stretching zone is set higher than the melting point of the said supplied fiber, and lower than the ... point of the fiber after stretching.

The polyethylene fiber of this invention demonstrates its effect by the fact that it is combined with other fibers that have characteristics that compensate for the weak points of the polyethylene fiber, and even in the case of only the polyethylene fiber, it has novel characteristics that hitherto did not exist. It is for instance combined with cotton that has dyability, moisture absorption and water absorption, and used as the core yarn. In this case, filaments of polyester fiber are arranged in the wick moiety of the core yarn, and cotton is arranged in the sheath moiety.

The core yarn can produce of fine yarn that hitherto did not exist, without loosing the appearance(?) of cotton. The polyethylene fiber in the wick moiety firmly holds the cotton, and by the flat state of the cross section of the polyethylene fiber and the multi-striate grooves of the surface, it reinforces the effects of moisture absorption and water absorption of cotton.

Moreover, in the case that only the polyethylene fiber of this invention is used and it is used in a rope for industrial materials, the fibers inside the rope are more elaborate than in ropes that are obtained from the existing fibers with a circular cross section, and because in addition, their strength is high, it is possible to obtain a fine, light weight, strong rope, and also with respect to the hand-touch of the rope, it is one that shows a hitherto unseen unique touch impression, and because ... the resistance of the rope against friction abrasion is excellent, the effect that the ropes durability is extremely long, is obtained.

In this way, the polyethylene fiber of this invention made it possible to adapt polyethylene fibers that hitherto were not suited for the field of clothing, for clothing. Moreover, even in the case of use of only polyethylene fibers, it is possible to obtain ones with an excellent resistance against friction abrasion, with a fineness, light weight and strength that hitherto were not found, and with a unique touch impression, and a wide range of use as industrial materials is wanted.

The methods of determination of the properties that were used for the evaluation of this invention are shown below.

<Method of determination of the characteristics of strong stretching of the fiber>

Tensilon, product of Toyo Holding Co., was used, and under the conditions of a length of the testmaterial (gauge length) of 30 mm, and a speed of stretching (elongation) of 100%/minute, the S-S curve of a single fiber was determined, and the tensile strength (g/d) and initial elasticity modulus (g/d) were calculated. The initial elasticity modulus was calculated from the maximum gradient in the vicinity of the point of origin of the S-S curve. The values of the respective characteristics are the average values that have been obtained by determinations in 20 single fibers.

<Method of determination of friction abrasion>

In the method of determination of friction abrasion, the single filament test material 2 is wound on chromium plated rod 1 with a diameter of 10 mm /ϕ, as is shown in figure 2, and one side of the single filament testmaterial is fixed, and to the other end, weight 3 of 5 g/d is suspended. The chromium plated rod performs an upward/downward reciprocating movement (stroke length 35 mm). The friction abrasion is expressed with the number of cycles of reciprocation from the start of the reciprocating movement until the single filament test material breaks.

Below, details of this invention are described by examples of execution, but this invention is of course not limited to these examples of execution.

Example of execution 1.

Polyethylene fibers with the characteristics of the thread for weaving that are shown in experiments 1 and 2 of table 1 were obtained by addition of liquid paraffin to a 3 wt% decalin solution of polyethylene with an ultrahigh molecular weight, with a weight average molecular weight of $1x10^6$, solution spinning with the use of this solution, and stretching of the obtained gel fiber under the conditions that are shown in experiments no. 1 and 2 of table 1. The obtained fibers were respectively set at 10 d/10 f. The quantity of liquid paraffin that was contained in the polyethylene fibers was 0.5 wt%.

A core yarn was produced with these polyethylene fibers respectively as the wick moiety, and arrangement of cotton of 1.9 d in the sheath moiety. The count (English system) of the core yarn was set at count 100. With the obtained core yarn as India(?) (Tenjiku(?)) knit, sports ware was produced. The results of tests of the strength of the weaving yarn, processability of the core yarn and appearance(?) wearing are shown in experiments 1 and 2 of table 1. As is clear from table 1, experiments 1 and 2 of this invention had an extremely good core yarn processability and knit wearability.

Example for comparison 1.

1-5 wt% decalin solutions of polyethylene with an ultrahigh molecular weight, with the same weight average molecular weight as the one that was used in example of execution 1, were prepared, liquid paraffin was added and solvent spinning was carried out. Under the conditions that are shown in experiments 3-6 of table 1, the obtained gel fibers were respectively stretched, and polyethylene fibers with the characteristics of the weaving thread that are shown in experiments 3-6 of table 1 were obtained. The obtained fibers were respectively set at 10 d/10 f. The quantity of liquid paraffin that was contained in the polyethylene fibers was 0.5 wt%. A core yarn was produced with these polyethylene fibers respectively as the wick moiety, and arrangement of cotton of 1.9 d in the sheath moiety, in the same way as in example of execution 1. The count (English system) of the core yarn was set at count 100. With the obtained core yarn as India(?) (Tenjiku(?)) knit, sports ware was produced. The results of tests of the strength of the weaving yarn, processability of the core yarn and appearance(?) wearing are shown in experiments 3-6 of table 1.

Because experiments 3 and 4 respectively have a tensile strength and initial elasticity modulus outside the range of this invention, processability in the case that it is used as the core yarn, is poor, and in the case of conversion to a knit, the evaluation of wearability of experiment 4 was not good. Experiment 5 is an example wherein the surface of the fiber does not have multi-striate grooves, and in the evaluation of knit wearability, it was not good, and because particularly the result of escape of moisture during wearing is poor, perspiration that has been produced was collected in the cloth and it gave an unpleasant impression. Experiment 6 is an example wherein the flattening rate is less than 1.7, and in the case of processing to a core yarn, the combinability with single cotton yarn is low, and in the case of wearing in sports ware, occurrence of fuzz was conspicuous. Moreover, also the fit and feel were not good.

Table 1.

	example of execution 1		example for comparison 1			
test no.	1	2	3	4	5	6
stretching conditions						
stretching temperature (° C) (first stretching zone)						
entrance	110	110	105	110	110	110
exit	130	130	135	130	130	130

stretching temperature (° C) (second stretching zone) entrance	115	115	-	-	115	115
exit	140	140	-	-	140	140
stretching temperature (° C) (third stretching zone) entrance	-	120	-	-	-	-
exit	-	145	-	-	-	-
total stretching rate	27.0	45	20	15	30	30
weaving yarn characteristics						
flattening rate of yarn's cross section	3.1	5.2	3.1	2.0	3.1	1.2
tensile strength (g/d)	30	35	25	15	30	32
initial elasticity modulus (g/d)	900	1100	700	600	900	1000
stretching rate (%)	7	6	15	20	7	6
presence/absence of multi-striate grooves	yes	yes	yes	yes	no	yes
processability of core yarn *	o	oo	Δ	Δ	o	Δ
knit wearability						
appearance(?) presence/absence of ...	yes	yes	yes	no	yes	yes
skin touch	good	good	good	fair-ly bad	bad	bad
fit and feel	a	a	a	b	c	d

(a: agreeable, b: common, c: fairly disagreeable, d: disagreeable)

* The evaluation of the processability of the core yarn is as follows:
- oo very good
- o good
- Δ bad
- x very bad

Example of execution 2.

Polyethylene fibers with the characteristics of the thread for weaving that are shown in table 2 were obtained by addition of various quantities of liquid paraffin to a 3 wt% decalin solution of polyethylene with an ultrahigh molecular weight, with a weight average molecular weight of $1x10^6$, solution spinning with the use of the thus obtained solutions, and stretching of the obtained gel fibers under the conditions that are shown in experiment no. 2 of example of execution 1. The obtained fibers were respectively set at 10 d/10 f. The quantity of liquid paraffin that was contained in these polyethylene fibers was calculated by extraction with xylene at room temperature. Moreover, verification of the liquid paraffin was assessed by the infrared absorption spectrum of the extract.

For polyethylene fibers with different contents of liquid paraffin, the evaluation of friction abrasion with a metal is shown in table 2. Because in experiment 8 the content of liquid paraffin is small, an effect thereof is not observed, as is clear from table 2.

Experiments 9-11 show a remarkable improvement of friction abrasion as compared with experiment 1, the case wherein absolutely no liquid paraffin is

present. Because in experiment 12 the content of liquid paraffin is high, the liquid paraffin adhered to the chromium rod, and it was not good.

Table 2.

experiment no.	content of liquid paraffin wt%	properties strength (g/d)	stretch (%)	initial modulus (g/d)	friction abrasion (cycles)
7	0	35	6	1100	50
8	0.005	35	5	1000	50
9	0.05	33	5	1100	70
10	0.50	31	5	900	90
11	1.00	30	6	900	90
12	1.50	25	10	800	85

Example of execution 3.

Polyethylene fibers with the characteristics of the thread for weaving that are shown in table 3 were obtained by solution spinning with the use of polyethylene with an ultrahigh molecular weight, with a weight average molecular weight of $2x10^6$, and stretching of the obtained gel fiber under the conditions that are shown in this table. With the use of the obtained fibers, 8 ... (casting(?), braided(?), whipped(?)) ropes were produced, following JIS L-2705. The properties of the obtained rope are shown in table 3.

As is clear from table 3, it is assessed that a rope with an extremely high strength is obtained in the case that the fiber of this invention has been turned into a rope.

Example for comparison 2.

With the use of a commercial polyethylene weaving thread that has the weaving thread properties that are shown in the column of example for comparison 2 of table 3, 8 ... (casting(?), braided(?), whipped(?)) ropes were produced, following JIS L-2705, in the same way as in example of execution 3. The properties of the obtained rope are shown in table 3.

As is clear from table 3, the rope of this example was one with a lower strength than the rope of example of execution 3.

Table 3.

	example of execution 3	example for comparison 2
stretching conditions		
stretching temperature (° C) (first stretching zone)		
entrance	110	-
exit	130	-
stretching temperature (° C) (second stretching zone)		
entrance	120	-
exit	135	-
stretching temperature (° C) (third stretching zone)		
entrance	125	-
exit	140	-
total stretching rate	45.0	-

weaving yarn characteristics		
flattening rate of yarn's cross section	5.6	1.0
tensile strength (g/d)	35	7.2
initial elasticity modulus (g/d)	1000	70.0
stretching rate (%)	5	15
presence/absence of multi-striate grooves	yes	no
knotting strength (g/d)	14.0	4.2
rope properties		
rope diameter (mm)	12	12
weight per 200 m (kg)	16.2	14.5
breaking force (t)	6.0	1.4

* Determination of properties of the rope according to JIS L-2705.

4. Brief description of the figures.

Figure 1 is the fiber of this invention, and it is a photograph by a scanning type of electron microscope with a 1500 x magnification, that shows a side surface and a cross section of the polyethylene fiber with a flattening rate of the cross section of the fiber of ca. 5.6.

Figure 2 is a scheme that shows the method of determination of friction abrasion that is used in the evaluation of this invention.

1 ... chromium plated rod
2 ... testmaterial, single filament
3 ... load

⑲日本国特許庁（JP）　⑪特許出願公開

⑫公開特許公報（A）　昭60－151311

⑤1Int.Cl.⁴	識別記号	庁内整理番号
D 01 F 6/46		6791－4L
// D 02 G 3/36		7107－4L

⑬公開　昭和60年(1985)8月9日

審査請求　未請求　発明の数 1　（全6頁）

⑭発明の名称　流動パラフインを含有するポリエチレン繊維

⑳特　願　昭59－5394

㉒出　願　昭59(1984)1月13日

㉒発明者　南　利　昇　佑　大津市堅田2丁目1番　D－301号

㉒発明者　川　口　時　夫　大津市堅田2丁目1番3号

㉒発明者　安　田　浩　大津市北大路3丁目9番2号

㉑出願人　東洋紡績株式会社　大阪市北区堂島浜2丁目2番8号

明　細　書

1. 発明の名称

流動パラフィンを含有するポリエチレン繊維

2. 特許請求の範囲

1. 繊維の断面の偏平化率が1.7以上であって、繊維表面に、繊維軸方向に配列された無数の微長の多条溝を有し、かつ、下記の特性を持つことを特徴とする流動パラフィンを含有するポリエチレン繊維。

繊維中の流動パラフィン含有量（LP）

$0.05 \leqq LP \leqq 1.00$（wt%）

引張強度　30（g／d）以上

初期弾性率　800（g／d）以上

2. 繊維の断面の偏平化率が2以上である特許請求の範囲第1項記載の流動パラフィンを含有するポリエチレン繊維。

3. 繊維の断面の偏平化率が3以上である特許請求の範囲第1項記載の流動パラフィンを含有するポリエチレン繊維。

4. 微長の多条溝が、繊維軸方向の長さの全領域にわたって実質的にすべて貫通している特許請求の範囲第1項乃至第3項のいずれかに記載の流動パラフィンを含有するポリエチレン繊維。

5. 微長の多条溝が、繊維横断面の外周方向の平均距離10μ当り5～50個配列している特許請求の範囲第1項乃至第4項のいずれかに記載の流動パラフィンを含有するポリエチレン繊維。

6. 引張強度が35（g／d）以上である特許請求の範囲第1項乃至第5項のいずれかに記載の流動パラフィンを含有するポリエチレン繊維。

7. 初期弾性率が1000（g／d）以上である特許請求の範囲第1項乃至第6項のいずれかに記載の流動パラフィンを含有するポリエチレン繊維。

3. 発明の詳細な説明

本発明は加工性に優れ、特に耐摩擦摩耗性に優れた流動パラフィンを含有するポリエチレン繊維に関する。

ポリエチレン繊維は、汎用高分子として安価であるが、染まらない、融点が低い、吸湿性がないなどの欠点を持つために他の合成繊維、例えば、

ポリエステル、ナイロン、アクリル繊維等のように衣料用としての使用は限しく、衣料用途以外の用途、例えば一般ロープ、漁網等に主として用いられている。この用途分野においてポリエチレン繊維は密度が1より低いため、特に水産資材用繊維として需要が大きい。しかし他の合成繊維、特にポリエステルやナイロン等と比較すると例えば最終製品であるロープの場合には、高密度ポリエチレンロープの強度は、該ポリエチレンロープと同等径のポリエステルロープの70%、ナイロンロープの50%程度しか得ることができず特に強度を必要とする分野への使用には限界があった。このようにポリエチレン繊維は従来使用分野が限定され需要も限られていた。一方、ポリエチレン繊維を衣料用に適用する場合、衣料用に不適当な機能や性能を改良するか、ポリエチレン繊維の有する特性を生かして、他の繊維と組合せて複合化して使用することが考えられる。この考え方に基づけば、ポリエチレン繊維の衣料用化にはポリエチレン繊維の持つ、他の合成繊維よりも密度が低いうえに、強度が比較的に高いといった該繊維の特性を生かしていくことが有利である。

本発明者らはポリエチレン繊維のもつ従来の欠点を解決すると共に該繊維の利点を生かして、さらに機能性を付与するべく、鋭意研究を重ねた結果、遂に本発明に到達した。

即ち、本発明は繊維の断面の偏平化率が1.7以上であって、繊維表面に、繊維軸方向に配列された無数の微長の多条溝を有し、かつ、下記の特性を持つことを特徴とする流動パラフィンを含有するポリエチレン繊維である。

繊維中の流動パラフィン含有量（LP）

$0.05 \leqq LP \leqq 1.00$ (wt%)

引張強度　30（g／d）以上

初期弾性率　800（g／d）以上

本発明のポリエチレン繊維は、従来公知のポリエチレン繊維と比較すれば、衣料用化の面で著しく加工性が改良されており、さらに、極めて高い引張強度、初期弾性率、かつ優れた耐摩擦摩耗性を示し、もちろん漁業資材用としても、強度、初期弾性率において優れた効果を発揮するものである。本発明のポリエチレン繊維が衣料用化の面で著しく加工性が優れる理由については、いまだ正確に解明していないが、本発明のポリエチレン繊維特有の繊維断面の偏平化と繊維表面に存在する繊維軸方向に配列された無数の微長の多条溝、それに加えて、流動パラフィンが大きく寄与しているものと推測している。

第1図は本発明の1実施様態より得られた繊維の断面の偏平化率が約5.6であるポリエチレン繊維の側表面と断面を示す1500倍での走査型電子顕微鏡写真である。該写真には本発明の繊維特有の繊維断面の偏平化と繊維表面に存在する繊維軸方向に配列された無数の多条溝がよくあらわれている。

本発明のポリエチレン繊維は第1図に示す如く断面が偏平であり、偏平化率が1.7以上、好ましくは2以上、更に好ましくは3以上である。偏平化率が大きいと、ポリエチレン繊維間の集束性が向上し、特に撚を付与した場合に繊維間のパッキング性が向上する。その効果は特に他の繊維と複合化した時に発揮する。偏平化率が1.7未満ではその効果が少なく、繊維断面が丸断面のものと大差がなくなる。

本発明で定義する偏平化率（$\overline{Ud}$）とは繊維軸に直角な横断面において長軸長さ（a□）と短軸の長さ（b□）を測定し、偏平化率（$\overline{Ud}$）はa／bで示す値である。

本発明におけるもう一つの特徴は第1図に見られる如く繊維表面の繊維軸方向に配列された無数の多条溝を有することである。ポリエチレン繊維は合成繊維独特のロウ状感を有し、平滑な表面の場合は不快感を与える。表面が平滑なポリエチレン繊維に多条溝を付与することによってこのロウ状感を減少し、さらに水分の漏れをよくする。この水分の漏れをよくする効果は他の繊維と複合化した場合に水分のトランスポートの役目を発揮する。又、ポリエチレン繊維に多条溝を付与すると繊維表面の摩擦係数が低下し、ガイド等の金属との摩擦抵抗が低くなり摩耗による繊維の損傷を減

少する。又他の繊維と複合化した場合、他の繊維とのからまりをよくし、さらに複合化繊維中のポリエチレン繊維束がしなやかな挙動を示す。

該多条溝は、繊維の横断面の外周方向の平均距離10μ当り2個以上、好ましくは5～50個配列していることにより、前記する効果、即ち、ロウ状感の減少、水分の濡れを良くする効果及び繊維表面の摩擦係数の低下効果等が極めて向上する。ここで多条溝が、繊維の横断面の外周方向の平均距離10μ当り2個未満の場合においては、ロウ状感の減少、水分の濡れを良くする効果及び繊維表面の摩擦係数低下効果は得られない。

本発明のポリエチレン繊維のさらにもう一つの特徴は流動パラフィンを含有していることである。本発明のポリエチレン繊維は、表面に多条溝を有することによる効果に加えて繊維中に流動パラフィンを含有することによる効果が相乗効果となって現われ、繊維の加工時における糸の走行張力を低下し、糸のダメイジを減少して安定な生産性を得ることができる。さらにポリエチレン繊維を単独で用いて得た製品も良好な耐反撥摩耗性を示す。

本発明のポリエチレン繊維は、繊維断面の全域にわたって流動パラフィンを含有していることが特徴である。従来後加工等で繊維表面のみに流動パラフィンを付与することによる摩擦摩耗性向上方法が知られているが、この場合は一時的効果にすぎず耐久性がなく好ましくない。これに対して本発明の繊維は耐摩擦摩耗の耐久性に極めて優れるものである。

本発明のポリエチレン繊維に含有されている流動パラフィンの含有量は0.05wt%以上1.0wt%以下が好ましい。流動パラフィンの含有量が0.05wt%未満では流動パラフィンの優れた耐摩擦摩耗効果が認められなくなるので好ましくない。又、流動パラフィンの含有量が1.0wt%を超える場合は流動パラフィンの含有量が多いので繊維表面にヌメリ感を与え、繊維加工時における糸の走行ガイドに流動パラフィンが堆積し操業性を悪くするので好ましくない。

本発明における流動パラフィンの含有量は次により求める。

ポリエチレン繊維を所定量採取し、繊維表面及び内面に含有している流動パラフィンを石油エーテル、キシレン、トルエン等の流動パラフィンを溶解する溶剤で抽出し、ポリエチレン繊維の初期の量（溶剤抽出前の量）に対する減量を測定し、これより算出する。又、流動パラフィンの確認は赤外吸収スペクトルによって判定する。

本発明のポリエチレン繊維の引張強度は30（g／d）以上、好ましくは35（g／d）以上が必要であって、ここで引張強度が30（g／d）未満にあっては、衣料用複合化した場合に細繊度、高強力による糸のスリム化効果が得られず、産業資材用の例えばロープに用いた場合にあっては細くて強靭なロープを得ることができない。

本発明のポリエチレン繊維の初期弾性率は800（g／d）以上、好ましくは1000（g／d）以上が必要であって、ここで初期弾性率が800（g／d）未満にあっては、繊維断面の偏平化との相乗効果により、繊維の腰が弱くなり、他の繊維と複合化した場合に、良好な風合が得られない。

本発明の繊維は、例えば高分子量のポリエチレン（例えば重量平均分子量が1×10^5以上、好ましくは1×10^6以上の超高分子量ポリエチレン）を用いて溶液紡糸する際、溶媒として揮発性溶剤を使用し、その溶液Jに延伸後の繊維中の流動パラフィン含有量が0.05wt%以上、1.0wt%以下となる適宜な量の流動パラフィンを添加して紡糸溶液を調合した後、溶液紡糸し、該溶液紡糸で製造したゲルファイバーを、延伸ゾーン入口温度を供給ファイバーの溶解点よりも高く、該供給ファイバーの融点より低い温度とし、延伸ゾーン出口温度を該供給ファイバーの融点よりも高く、延伸後ファイバーの融点よりも低い温度とした延伸ゾーンを通過させながら多段延伸をするといった新規な高倍率延伸方法によって得られる。

本発明のポリエチレン繊維は、ポリエチレン繊維の欠点をおぎなう特性を有する他の繊維と複合することによりその効果を発揮し、ポリエチレン繊維単独でも従来にない新規な特性を有している。

例えば染色性、吸湿性、吸水性を有する木綿と複合化し、コアヤーンとする。この場合、コアヤーンの芯部にポリエチレン繊維のフィラメントを配し、鞘部に木綿を配する。

コアヤーンは木綿の風合をそこなうことなく従来にない細い糸を作ることができる。芯部にあるポリエチレン繊維は木綿を強く保持し、ポリエチレン繊維の断面の偏平形状と表面の多条溝により木綿の吸湿性、吸水性の効果を助ける。

さらに本発明のポリエチレン繊維を単独で使用し、産業資材用のロープに用いた場合、従来の丸断面の繊維から得られるロープよりもロープ内の繊維が細密化され、その上強度が高いので細くて軽い強靭なロープを得ることができるし、ロープの手触りも従来に見ない独特のタッチ感を示すものであり、就中、ロープの耐摩擦摩耗性が優れているため、ロープの耐用寿命が著しく長いという優れた効果が得られる。

このように本発明のポリエチレン繊維は従来衣料用分野には不向きであったポリエチレン繊維を衣料用として適応可能にすることができた。さらにポリエチレン繊維を単独で使用する場合も耐摩擦摩耗性に優れ従来に見ない細くて軽く強靭でさらに独特のタッチ感を有するものを得ることが出来、産業資材用として広範な利用が望める。

本発明の評価に用いた物性の測定方法は以下による。

＜繊維の強伸度特性の測定法＞

東洋ボールドウィン社製テンシロンを用い、試料長（ゲージ長）３０㎜、伸長速度１００％／分の条件で単繊維のＳ－Ｓ曲線を測定し、引張強度（ｇ／ｄ）、初期弾性率（ｇ／ｄ）を算出した。初期弾性率は、Ｓ－Ｓ曲線の原点付近の最大勾配より算出した。各特性値は２０本の単繊維について測定したものの平均値とした。

＜摩擦摩耗の測定法＞

摩擦摩耗の測定法は第２図に示す如く、直径１０㎜φのクロムメッキ棒１に試料単フィラメント２を１回巻付け、試料単フィラメントの一方を固定し、もう一方に５ｇ／ｄの荷重３を掛ける。クロムメッキ棒は上下の往復運動（ストローク長３５㎜）をする。摩擦摩耗はクロムメッキ棒が往復運動始めてから試料単フィラメントが切断するまでの往復回数で表示する。

以下本発明を実施例により詳述するが、本発明はもとより、これらの実施例に限定されるものではない。

実施例１

重量平均分子量が1×10^6の超高分子量ポリエチレンの３wt％デカリン溶液に流動パラフィンを添加し、この溶液を用いて溶液紡糸し、得られたゲルファイバーを第１表の実験No.１及び２に示す条件で、それぞれ延伸し、第１表実験No.１，No.２に示す原糸特性をもつポリエチレン繊維を得た。得られた繊維はそれぞれ１０ｄ／１０ｆとした。ポリエチレン繊維に含有されている流動パラフィンの量は0.5 wt％であった。

これらのポリエチレン繊維をそれぞれ芯部とし、さや部に1.9 ｄの木綿を配しコアヤーンとなした。コアヤーンの番手（英式）は100番手とした。得られたコアヤーンを天竺ニットとし、スポーツウエアーを作成した。原糸強度とコアヤーン加工性及び風合い着用テスト結果を第１表の実験No.１～２に示す。第１表から明らかなように本発明の実験No.１～２はコアヤーン加工性、ニット着用性に極めて優れている。

比較例１

実施例１で用いたものと同じ重量平均分子量の超高分子量ポリエチレンを１～５wt％のデカリン溶液とし、流動パラフィンを添加して溶液紡糸した。得られたゲルファイバーを第１表の実験No.３～６に示す条件でそれぞれ延伸し、第１表実験No.３～６に示す原糸特性をもつポリエチレン繊維を得た。得られた繊維はそれぞれ１０ｄ／１０ｆとした。ポリエチレン繊維に含有されている流動パラフィンの量は0.5 wt％であった。これらのポリエチレン繊維を、実施例１と同様にそれぞれ芯部とし、さや部に１９ｄの木綿を配しコアヤーンとなした。コアヤーンの番手（英式）は100番手とした。得られたコアヤーンを天竺ニットとし、ス

ボーツウエアーを作成した。原糸強度とコアヤーン加工性及び風合い着用テスト結果を第1表の実験No3～6に示す。

実験No3，No4はそれぞれ引張強度及び初期弾性率が本発明を外れるもので、コアヤーンとする場合の加工性が劣り、さらに実験No4はニットにした場合、着用性の評価は良くなかった。実験No5は、繊維の表面に多条溝を有しない例であって、ニット着用性評価は良いものではなく、特に着用時水分の漏れ効果が劣るために発汗した汗が布地にたまり不快感を与えるものであった。実験No6は繊維の偏平化率が1.7未満の例であって、コアヤーンに加工の際、木綿単糸との結合性が低下し、スポーツウエアにして着用した場合、毛羽立ちが目立った。又着心地も良くなかった。

<第1表>

			実施例1		比較例1			
実験No.			1	2	3	4	5	6
延伸条件	延伸温度(℃)（第1延伸ゾーン）	入口	110	110	105	110	110	110
		出口	130	130	125	180	130	130
	延伸温度(℃)（第2延伸ゾーン）	入口	115	115	—	—	115	115
		出口	140	140	—	—	140	140
	延伸温度(℃)（第3延伸ゾーン）	入口	—	120	—	—	—	—
		出口	—	145	—	—	—	—
	トータル延伸倍率		27.0	45	20	15	30	30
繊維特性	糸断面偏平化率		3.1	5.2	3.1	2.0	3.1	1.2
	引張強度（g/d）		30	35	25	15	30	32
	初期弾性率（g/d）		900	1100	700	600	900	1000
	伸度（%）		7	6	15	20	7	6
	多条溝の有無		有	有	有	有	無	無
コアヤーンの加工性*			○	○	△	△	○	△
ニット着用性	風合い	口の有無	有	有	有	無	有	有
		肌ざわり	良	良	良	やや不良	不良	不良
	着心地		快適	快適	快適	快適	やや不快	不快

*コアヤーン加工性の評価は次のとおりとした。

（◎非常に良い　○良い　△良くない　×非常に良くない）

実施例2

重量平均分子量が1×10^6の超高分子量ポリエチレンの3 wt%デカリン溶液に流動パラフィンを種々添加量を変更して得た溶液を用いて溶液紡糸し、得られたゲルファイバーを実施例1の実験No2に示す条件で、それぞれ延伸し、第2表に示す原糸特性をもつポリエチレン繊維を得た。得られた繊維はそれぞれ10d／10fとした。これら繊維の含有流動パラフィン量はキシレンで常温抽出し計算した。又流動パラフィンの確認は抽出液の赤外吸収スペクトルによって判定した。

流動パラフィン含有量の違うポリエチレン繊維について金属との摩擦摩耗性の評価を第2表に示す。第2表から明らかなように実験No8は流動パラフィンの含有量が少ないためその効果は認められない。実験No9～11は流動パラフィンを全く含まない場合の実験No7に比べて摩擦摩耗性の向上が顕著に認められる。実験No12は流動パラフィンの含有量が多いためにクロム棒に流動パラフィンが付着して好ましくなかった。

<第2表>

実験No.	流動パラフィン含有量 wt%	物性			摩耗回数（回数）
		強度（g/d）	伸度（%）	初期モジュラス（g/d）	
7	0	35	6	1100	50
8	0.005	35	5	1000	50
9	0.05	33	5	1100	70
10	0.50	31	5	900	90
11	1.00	30	6	900	90
12	1.50	25	10	800	85

実施例3

粘度平均分子量が2×10^6の超高分子量ポリエチレンを用いて溶液紡糸し、得られたゲルファイバーを第3表に示す条件で延伸し、同表に示す原糸特性をもつポリエチレン繊維を得た。得られた繊維を使用して、JIS L−2705に従い、8つ打ちロープを作成した。得られたロープ特性を第3表に示す。

第3表から明らかな如く、本発明の繊維はロープとした場合、極めて高強力なロープが得られることが判る。

比較例2

第3表の比較例2の欄に示す原糸特性を有する市販のポリエチレン原糸を用いて、実施例3と同様にJIS L−2705に従い、8つ打ロープを作成した。得られたロープ特性を第3表に示す。

第3表から明らかな如く、本例のロープは、実施例3のロープに比較して極めて強度が劣るものであった。

<第3表>

			実施例3	比較例2
延伸条件	延伸温度(℃)（第1延伸ゾーン）	入口	110	−
		出口	130	−
	延伸温度(℃)（第2延伸ゾーン）	入口	120	−
		出口	135	−
	延伸温度(℃)（第3延伸ゾーン）	入口	125	−
		出口	140	−
	トータル延伸倍率		45.0	−
原糸特性	糸断面扁平化率		5.6	1.0
	引張強度（g/d）		35	7.2
	初期引張率（g/d）		1000	700
	伸度（%）		5	15
	多糸切の有無		有	無
結節強度（g/d）			140	4.2
ロープ特性	ロープ直径（mm）		12	12
	200m当り重量（kg）		16.2	14.5
	破断力（t）		6.0	1.4

＊ロープの物性測定はJIS L−2705による。

4. 図面の簡単な説明

第1図は本発明の繊維であって、繊維の断面の偏平化率が約5.6であるポリエチレン繊維の側表面と断面を示す1500倍での走査型電子顕微鏡写真である。

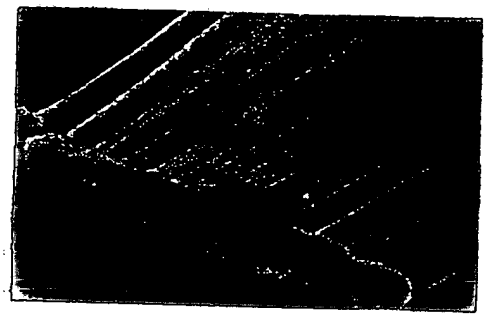
第2図は本発明の評価に用いた摩擦摩耗の測定方法を示す概略図である。

1…クロムメッキ棒

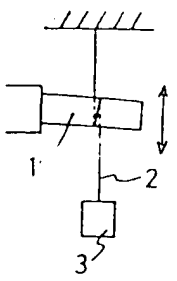
2…試料単フィラメント

3…荷重

第1図



第2図



特許出願人　東洋紡績株式会社